perature of the arc, fused down to a heavy semi-metallic mass, which having been examined, and found not to be the substance sought, was thrown into a bucket containing water, with the result that violent effervescence of the water marked the rapid evolution of a gas, the overwhelming odour of which enforced attention to its presence, and which, on the application of a light, burnt with a smoky, but luminous flame.

Investigation into the cause of this phenomenon soon showed that in a properly constructed electric furnace, finely ground up chalk or lime, mixed with powdered carbon in any form, whether it were charcoal, anthracite, coke, coal, or graphite, can be fused with the formation of a compound known as calcic carbide, containing 40 parts by weight of the element calcium, the basis of lime, and 24 parts by weight of carbon, and that, on the addition to this of water, a double decomposition takes place, the oxygen of the water combining with the calcium of the calcic carbide to form calcic oxide or lime, whilst the hydrogen unites with the carbon of the calcic carbide to form acetylene, the cost of the gas so produced bringing it not only within the range of commercial possibilities for use *per se*, but also the building up from it of a host of other compounds, whilst the production of the calcic carbide from chalk and from any form of carbon, renders us practically independent of coal and oil, and places in our hands the prime factor by which nature in all probability produces those great underground storehouses of liquid fuel upon which the world is so largely drawing to-day.

Calcic carbide is a dark grey substance, having a specific gravity of 2·262, and, when pure, a pound of it will yield on decomposition 5·3 cubic feet of acetylene. Unless, however, it is quite fresh, or means have been taken to carefully protect it from air, the outer surface gets slightly acted upon by atmospheric moisture, so that in practice the yield would not exceed five cubic feet. The density and hardness of the mass, however, protects it to a great extent from atmospheric action, so that in lumps it does not deteriorate as fast as would be expected, but in the powdered condition it is rapidly acted upon.

The acetylene made from it, when analysed by absorption with bromine, the analysis being also checked by determining the amount present by precipitation of silver acetylide, gives 98 per cent. of acetylene and 2 per cent. of air, and traces of sulphuretted hydrogen, the presence of this impurity being due to traces of sulphate of lime—gypsum—in the chalk used for making it, and to pyrites in the coal employed.

Acetylene is a clear, colourless gas with an intensely penetrating odour which somewhat resembles garlic, its strong smell being a very great safeguard in its use, as the smallest leakage would be at once detected; indeed, so pungent is this odour, that it would be practically impossible to go into a room which contained any dangerous quantity of the gas.

This is an important point to remember, as the researches of Bistrow and Liebreich show that the gas is poisonous, combining with the hæmoglobin of the blood to form a compound similar to that produced by carbon monoxide; whilst the great danger of the latter gas is that having no smell, its presence is not detected until symptoms of poisoning begin to show themselves, so that no fear need be apprehended of danger from this source with acetylene.

Acetylene is soluble in water and most other liquids, and at ordinary temperature and pressure—60° F. and 30 inches of mercury—10 volumes of water will absorb 11 volumes of the gas; but as soon as the gas is dissolved, the water being saturated takes up no more. Water already saturated with coal-gas does not take up acetylene quite so readily, whilst the gas is practically insoluble in saturated brine—100 volumes of a saturated salt solution only dissolving 5 volumes of the gas. The gas is far more soluble in alcohol, which at normal temperature and pressure takes up six times its own volume of the acetylene, whilst 10 volumes of paraffin under the same conditions will absorb 26 volumes of the gas. It is a heavy gas, having a specific gravity of 0·91.

When a light is applied to acetylene, it burns with a luminous and intensely smoky flame, and when a mixture of one volume of acetylene with one volume of air is ignited in a cylinder, a dull red flame runs down the cylinder, leaving behind a mass of soot, and throwing out a dense black smoke. When acetylene is mixed with 1·25 times its own volume of air, the mixture begins to be slightly explosive, the explosive violence increasing until it reaches a maximum with about twelve times its volume of air, and gradually decreases in violence until, with a mixture of one volume of acetylene to twenty of air, it ceases to be explosive.

The gas can be condensed to a liquid by pressure, Andsell finding that it liquefied at a pressure of 21·5 atmospheres, at a temperature of 0° C., whilst Cailletet found that at 1° C. it required a pressure of 48 atmospheres, the first-named pressure being probably about the correct one. The liquid so produced is mobile, and highly refractive, and when sprayed into air, the conversion of the liquid into the gaseous condition absorbs so much heat that some of the escaping liquid is converted into a snow-like solid, which catches fire on applying a light to it, and burns until the solid is all converted into gas and is consumed.

In my researches upon the luminosity of flame, I have shown that all the hydrocarbons present in coal-gas and other luminous flames are converted by the baking action taking place in the inner non-luminous zone of the flame into acetylene before any luminosity is produced, and that it is the acetylene which by its rapid decomposition at 1200° C. provides the luminous flame with these carbon particles, which, being heated to incandescence by various causes, endow the flame with the power of emitting light. The acetylene, being in this way proved to be the cause of luminosity, one would expect that in this gas we have the most powerful of the gaseous hydrocarbon illuminants; and experiment at once shows that this is the case.

Owing to its intense richness, it can only be consumed in small flat flame burners, but under these conditions emits a light greater than that given by any other known gas, its illuminating value calculated to a consumption of 5 cubic feet an hour being no less than 240 candles.

Illuminating Power of Hydrocarbons for a Consumption of 5 cubic feet of Gas.

	Candles.
Methane	5·2
Ethane	35·7
Propane	56·7
Ethylene	70·0
Butylene	123·0
Acetylene	240·0

It is stated that the carbide can be made at about £4 a ton; and if this be so, it should have a great future, as a ton will yield 11,000 cubic feet of the gas. The lime left as a bye-product would be worth 10*s*. a ton, and the gas would cost at this rate 6*s*. 4½*d*. per 1000 cubic feet, and in illuminating value would be equal to London coal gas at 6*d*. a thousand. Its easy production would make it available for illuminating purposes in country houses, whilst its high illuminating value should make it useful for enriching poor coal gas.

CHEMICAL CHANGES BETWEEN SEA-WATER AND OCEANIC DEPOSITS.[1]

The numerous analyses of sea-water by Forchhammer previous to 1865, and the later analyses by Dittmar, from samples collected during the *Challenger* Expedition, show that while the *salinity*—*i.e.* the amount of dissolved salts contained in 100 parts of sea-water—varies greatly in different regions of the ocean, still the composition of these dissolved salts—*i.e.* the ratio of the constituents of sea-salts—remains practically the same in all the superficial waters of the ocean. Consequently, it is only necessary to determine the chlorine in a definite weight of water to ascertain at once the respective quantities of the other salts present in the sample. Dittmar's examination of the *Challenger* waters has, however, shown that lime is slightly, although distinctly, more abundant in samples of sea-water collected in greater depths than in those samples collected nearer the surface of the ocean, and Dittmar's tables showing the difference between the chlorine calculated from the specific gravity and the chlorine found by analysis[2] point to differences in the composition of the sea-salts; but the observations are relatively so few, these differences so slight, so mixed up with observational errors, and so irregular in their geographical and bathymetrical distribution, that they cannot be said to indicate any general law other than a greater quantity of lime in deep water.

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[1] Abstract of a Paper read before the Royal Society of Edinburgh on March 7, 1892, by Dr. John Murray and Robert Irvine, and published in *Trans.*, vol. xxxvii. part 2, No. 23.

[2] Dittmar, "*Challenger* Report on the Composition of Ocean Water," "Phys. Chem. *Chall.* Exp.," part 1, p. 43.

But there is abundant evidence that great changes in chemical composition take place in the substances deposited on the floor of the ocean, and, with the view of throwing some light on the manner in which these changes are brought about, it occurred to us to examine the composition of the sea-water associated or mixed up with marine deposits on the floor of the ocean, and especially with that variety of marine deposits known as Blue Mud.

The depth at which a fine blue mud may form in the sea, depends entirely on the depth of water and the extent of the basin; or, in other words, on the height and length of the waves.[1] In harbours it may be deposited not deeper than 1 or 2 fathoms, while along the western coasts of Scotland and Ireland, which are exposed to the waves of the wide and deep Atlantic, the true mud-line may be situated at a depth of about 150 or 200 fathoms.

In this paper we state the results of our investigation into the composition of the sea salts in samples of water enclosed in the blue muds from Granton Harbour and Quarry, near Edinburgh, at Queensferry, N.B., and other places. The water was obtained by filling a canvas bag with the mud and collecting the water which filtered through, the first portions being rejected.

The Specific Gravity of the filtrate was about normal for in-shore water, ranging from 1024 to 1026.

Chemical Composition of the Sea-water Salts in Mud-water.—On comparison with normal sea-water salts, the sulphates were greatly reduced, while the alkalinity (combined carbonic acid) was correspondingly increased, sometimes rising to ten times above the normal.

When a portion of the clear water filtered from the harbour muds was boiled, a precipitate was thrown down in a crystalline form, consisting of carbonates of lime and magnesia in the following proportions:—

$CaCO_3$	73·30
$MgCO_3$	26·70
	100·00

Before boiling, the water had an alkalinity of 0·7760 grms. per litre, while after boiling it showed an alkalinity of only 0·2200 grms., thus proving that the alkalinity was mainly due to the formation and presence of these carbonates rendered soluble by free carbonic acid.

Saline and albumenoid ammonia ranged from 4 to 80 parts, and 1 to 5 parts per million, respectively. Lime was much less, and magnesia slightly less than the normal. The chlorine and the total bases were higher than normal water of equal density. Bicarbonate of manganese was present in the water up to 1 part in 16,000. Normal sea-water contains no manganese.

The following table gives a comparison of the composition of normal and mud-waters:—

	Average sea-water.[2]	Mud-water.
Sodium chloride, NaCl	77·758	79·019
Magnesium ,, $MgCl_2$	10·878	11·222
Magnesium bromide, $MgBr_2$ ...	0·217	0·220
Magnesium sulphate, $MgSO_4$ ...	4·737	3·232
Potassium ,, K_2SO_4 ...	2·465	2·506
Ammonium ,, $(NH_4)_2SO_4$	...	0·206
Magnesium carbonate, $MgCO_3$ ...	...	0·729
Calcium ,, $CaCO_3$ ...	0·345	2·686
Calcium sulphate, $CaSO_4$ ...	3·600	...
Manganous carbonate, $MnCO_3$ ...	...	0·180
	100·000	100·000

It will be seen that the total salts of the mud-water are low in proportion to the chlorine, consequently the D value—that is, the density minus 1000 divided by the chlorine—will be lower than normal water. In normal water the D value is 1·457, in mud water 1·430.

The reactions that take place in Blue Muds seem to be the following, and may be distinctly proved from the analyses of mud-water, as well as from a consideration of the whole subject. During the process of decomposition it appears that the greater part of the oxygen for the oxidation of the carbon and hydrogen of the organic substances in the blue muds is derived from the sulphur salts of the alkaline and earthy alkaline metals in sea-water, which, in the first instance, are reduced to the form of sulphides. These sulphides, owing to their instability, especially in the presence of free or loosely-combined carbonic acid, are decomposed as formed. The sulphur thus reduced from the sulphates may in part, on passing as hydrosulphuric acid into the water immediately above the mud, become oxidised back again into sulphuric acid, which in turn, decomposing the carbonate of lime always present in the water (or in the deposit), would re-form sulphates.

This oxidation is effected but slowly, as the following laboratory experiments show:—

Exp. I.—A solution of hydrosulphuric acid (H_2S) in pure water, which at first gave no precipitate with barium chloride, after standing a month, gave a distinct precipitate of barium sulphate, showing that the hydrosulphuric acid had been oxidised into sulphuric acid (SO_3).

Exp. II.—A solution of hydrosulphuric acid in sea-water was exposed to the air till complete oxidation had taken place. On titration the sea-water had lost its alkalinity, the sulphuric acid being proportionately increased.

Exp. III.—Hydrosulphuric acid was passed into water holding carbonates of calcium and magnesium in suspension, and resulted in a yellowish solution of the sulphides of calcium and magnesium, carbonic acid being expelled. The sulphides so formed were in turn decomposed by excess of carbonic acid, with evolution of hydrosulphuric acid, bicarbonates being formed, the reaction apparently depending on which acid is in excess.[1]

A certain part of the sulphides, or it may be of hydrosulphuric acid, derived from the soluble sulphides by the action of the free carbonic acid present in the mud, reduces the ferric oxides of the deposit, forming sulphide of iron, which so long as it is not exposed to the action of oxygen, remains stable, being in this respect unlike sulphide of manganese.[2] The sulphide of iron gives the characteristic blue-black colour to the great majority of the blue muds, especially where there is abundance of organic matter. It is by this process that sulphur is continually being abstracted from sea-water and locked up in marine deposits, which may finally be converted into blue-coloured shales, schists, and marls.[3] In these rocks the crystalline pyrites (FeS_2) has evidently its origin in the processes of death and decay going on at the time of their deposition at the sea-bottom, the sulphur of the sulphide of iron being derived from the sulphates of the sea-water, and not from the sulphur of the organisms, as generally supposed. This decomposition seems to be due to the action of bacteria in causing putrefactive changes in dead organic matter. We have found that if sea-water containing putrescible organic matter be sterilised by boiling, and thereafter care be taken to prevent the ingress of bacteria to this cooled liquid, the changes above indicated do not take place. Apparently the organic matter must be broken down by bacteria into its component elements, which in the nascent condition are capable of reducing the sulphates to a lower form of combination. The bisulphide of iron in the coal measures has without doubt a similar origin.

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[1] See Murray and Renard, "*Challenger* Report on Deep-Sea Deposits," p. 185. (London, 1891.)

[2] See Dittmar, *op. cit.* pp. 137-138 and 203.

[1] See also *Comptes rendus*, tom. lxxxiii. pp. 58 and 345 (1876). Note by Naudin and Montholon; also Sainte Claire Deville, *Leçons sur la Dissociation*, 1864.

[2] Irvine and Gibson, *Proc. Roy. Soc. Edin.* p. 37, 1891.

[3] The black or dark blue colour of many shales and schists is due principally to the presence of iron, either combined with silica as silicate, or more rarely in the condition of carbonate or oxide. These shales, schists, &c., contain organic matter in a state of decomposition. In the older rocks its condition nearly approaches that of graphitic carbon; in a dark schist from Argyllshire only 0·91 per cent. of *graphitic* organic matter was found. In the more recent formations the organic matter, if in sufficient quantity, may give rise to the formation of petroleum. See paper by Dr. J. J. Jahn, *Jahrbuch der K.K. Geolog. Reichsanstalt*, 1892, Bd. 42, Heft 2.

The principal reactions which occur in mud-waters may be explained by the following formulæ :—

$$(1)\ RSO_4 + 2C = 2CO_2 + RS,$$

where R is an earthy alkaline metal.

$$(2)\ RS + 2CO_2 + H_2O = H_2S + RCO_3CO_2.$$
$$(3)\ RS + RCO_3CO_2 + H_2O = 2RCO_3 + H_2S.$$

On the hydrosulphuric acid meeting with ferric oxide (Fe_2O_3) present in the surface layer of these blue muds the following reaction occurs :—

$$(4)\ Fe_2O_3 + 3H_2S = 2FeS + S + 3H_2O.$$

Part of the sulphur is thus fixed in the mud, and part, if there be not sufficient iron in the mud, may escape into the water above, where, meeting oxygen, it will be converted into sulphuric acid (H_2SO_4), and return into RSO_4. The products RCO_3CO_2 in (2), and RCO_3 in (3), or the bicarbonate and carbonate of the metal are found in the water strained from the mud.

The increase of alkaline ammoniacal salts points, however, to a further reaction, by which carbonate of lime is increased in a slight degree, for as ammonium carbonate [$(NH_4)_2CO_3$] is formed by the decomposition of the albuminoids present, the sulphates in the sea-water by this means are decomposed, sulphate of ammonia [$(NH_4)_2SO_4$] and earthy carbonates being the result.

In the red muds and clays, either from the abundance of oxygen in the superincumbent waters, from the ochreous matter present in the mud or clay, or from the organic matter being small in quantity, the sulphide of iron is either not formed, or is after formation soon oxidised into ferric hydrate, which then gives its characteristic red colour to these deposits.

It may be accepted as the rule that muds containing a large amount of organic matter relatively to the iron present invariably partake of the characteristic blue-black colour, whilst if organic matter be low in amount, or altogether absent, the black sulphide is either not formed at all, or is oxidised into peroxide of iron.

Our attention has been recently drawn to a most interesting paper, read before the British Association, Edinburgh (1892) meeting, by N. Andrussow, on the "Russian Exploration of the Black Sea."[1]

The condition of the water in the Black Sea below the 100-fathom line, in which hydrosulphuric acid and sulphides exist in great abundance, is due to the same action as that now being carried on so widely in the formation of the blue muds on the ocean floor, viz. the deoxidation of the sulphates in the water by organic matter, and not, as stated in Andrussow's paper, as simply the decomposition-products after death of a great number of organisms. But a compound or double reaction appears in this instance to be taking place, viz.—

Firstly, on those portions of the bottom within a moderate distance from the shore, ordinary blue mud containing sulphide of iron (in large amount) is being deposited.

Secondly, in the deep water, especially far from the shore, below a depth of 100 fathoms where the oxygen has been used up, the hydrosulphuric acid, not having enough iron present in the floating mud to combine with, or to fix it as sulphide of iron (FeS), is found in the free condition. At the same time there must be a large quantity of free or loosely-combined carbonic acid in the water, the result of the deoxidation of the sulphates by organic matter, which naturally would decompose the sulphides at their inception (or as these are formed). That this is probably the case appears from the fact that in the greater depths of the Black Sea, far from land, there exists a large deposit of mud consisting principally of carbonate of lime, precipitated from its waters, which hold in solution lime and other salts as well as hydrosulphuric and carbonic acids. In the laboratory experiments noted above we have the rationale of these conditions. The deep water in the Black Sea may be thus in a state of continual change, the alkalinity in this case being due either to sulphides or carbonates in so far as carbonic acid or hydrosulphuric acid predominates, and not wholly to carbonic acid as in the open ocean, where sulphides cannot remain permanent owing to the constant excess of oxygen present ; but it is evident that, since the light grey mud consists principally of carbonate of lime, the carbonic acid must, it may be on account of the pressure or temperature, have had the advantage over the hydrosulphuric acid.

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[1] "On Deep-Sea Research in the Black Sea," giving the results of an expedition (under the superintendence of Colonel J. B. Spindler) sent out by the Russian Government in 1890 and 1891. These results have already been partly published in the preliminary transactions of the Russian Geographical Society (in Russian), the physical results in German by Prof. Woicjkoff in *Petermann's Mitteilungen*. An abstract of Andrussow's paper has been published in the Royal Geographical Society's *Journal*, January 1893, giving a very fair epitome of the various points dealt with.

METEOROLOGICAL WORK IN AUSTRALIA.[1]

THE object of the present paper is to place before the Association a brief and succinct account of meteorological work in Australia. Mr. Russell has already told us, in his interesting paper on astronomical and meteorological workers, read before the Association at its first meeting in Sydney in 1888, what had been done in the early days of the mother colony, and brings the history up to the year 1860, or immediately following the commencement of the active work of the new observatory completed in 1858, an establishment with which he has been associated during the past thirty-four years, and over which he has presided since his appointment as astronomer in 1870, on the death of Mr. Smalley in July of that year.

It is unnecessary that I should travel over the same ground. My intention is to carry on the history of which Mr. Russell has already given us the opening chapter. Indeed, as regards meteorology but little had been done before the advent of Mr. Scott, the first Director of the Sydney Observatory, in 1858, who, Mr. Russell tells me, established twelve meteorological stations, two of which, Brisbane and Rockhampton, were in Queensland, then forming part of New South Wales. Each station was equipped with a standard barometer, dry and wet bulb thermometers, maximum and minimum thermometers, and a rain gauge.

Meteorological stations had previously—in 1840—been established at South Head, Port Macquarie, and Port Phillip, Victoria being then under the Government of New South Wales. The observations at South Head were kept up, but, I fear, not in a very satisfactory or systematic manner, for fifteen years, or until 1855. At Port Phillip and Port Macquarie they are said to have been discontinued after six years. During Mr. Smalley's tenure of office several stations started by his predecessor, for some reason or other, probably owing to his bad health, were closed or allowed to fall into disuse. These were, however, speedily re-established by Mr. Russell : and I may here mention, as showing the active manner in which that gentleman has prosecuted the work commenced by Mr. Scott, that he has now, in addition to the Sydney Observatory, thirty-five meteorological stations, having barometers, dry and wet bulb thermometers, maximum and minimum thermometers, and rain gauges ; 139 stations furnished with thermometers and rain gauges ; and 1063 stations having rain gauges.

The Sydney Observatory is equipped with continuous self-recording barograph and thermograph, pluviometer and anemograph, made after Mr. Russell's own designs, besides underground thermometers at depths of 10 feet, 5 feet, 2 feet 6 inches, and 1 inch ; an evaporation tank, or atmometer, &c. ; a record, combined with the valuable astronomical work being done, worthy of the oldest colony of the group, which had already gained distinction in its promotion of science by the Dawes Point Observatory, erected in 1788, and the celebrated Paramatta Observatory, established in 1821 by Sir Thomas Brisbane.

In Mr. Tebbutt, Mr. Russell has found a most valuable coadjutor. That gentleman has not only carried out an extensive series of astronomical observations entirely at his own cost, but also furnished his observatory with a complete meteorological outfit.

In Victoria there were only broken records of rainfall, temperature, and weather, made chiefly by New South Wales officials in Melbourne, from 1840 to about 1849, and of rainfall up to 1851. In 1854 observations of barometer and temperature for astronomical purposes only, and of rainfall, were made at the Williamstown Observatory, then in charge of Mr. R. L. J. Ellery. Meteorological observations were also made at Melbourne by Mr. Brough Smyth, of the Crown Lands De-

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[1] Abstract of a Paper read before the Australasian Association for the Advancement of Science, by Sir C. Todd, K.C.M.G., F.R.S. ;